THE ATOM GIVES UP

By William L. Laurence

ON SUNDAY, May fifth, on the eve of one of the greatest upheavals in man's history, the world learned about the discovery of a new source of power, millions of times greater than anything known on earth. A newly extracted natural substance, present in relative abundance in many parts of the world, but very difficult to isolate, had been found capable of liberating energy at such an unbelievable rate that one pound of it was the equivalent of 5,000,000 pounds of coal or 3,000,000 pounds of gasoline. In explosive power one pound of the new substance would be equal to 15,000 tons of TNT. Only one chief obstacle remained—to find a method for isolating the substance in large quantities, and scientists were hopeful that such a method would not be long in developing.

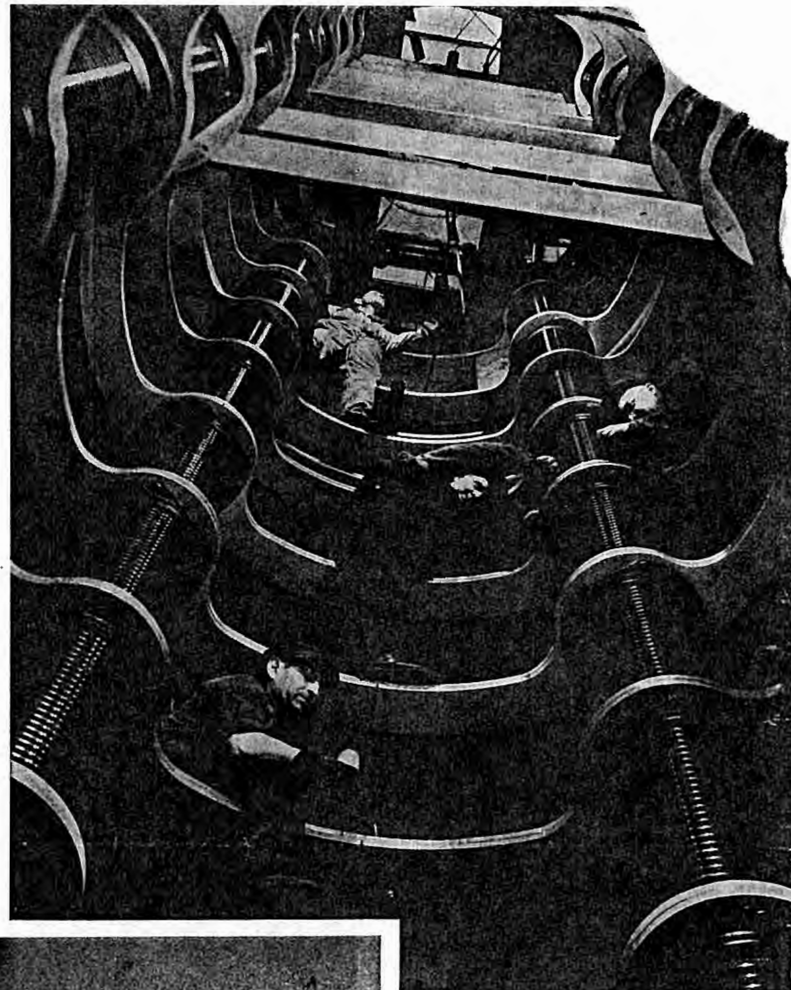
The name of the new substance, a veritable Prometheus bringing to man a new form of Olympic fire, is uranium 235, or U-235 for short. It is a rare form of uranium, each 140 pounds of uranium containing one pound of U-235. It differs from uranium in its atomic weight, ordinary uranium being 238 times as heavy as hydrogen (the lightest of the ninety-two elements), whereas U-235 weighs 235 times as much as hydrogen. Hence the name. Even the existence of U-235 was not known until 1935, when it was discovered by means of a highly ingenious "atomic microscope" by Prof. Arthur J. Dempster, at the physics laboratory of the University of Chicago. There was not the slightest reason at the time to expect anything unusual from this newly found relative of the royal uranium family of elements.

The complete story behind the story of this astonishing development, that may turn out later to be "the greatest story in the world," has until now remained largely untold. The story had its beginning about a year and a half ago, in Berlin, with experiments on uranium conducted by Dr. Lise Meitner and Prof. Otto Hahn, a scientific team that had worked together for twenty years. Like many an explorer before them, among whom Columbus is the best known example, they were seeking a new route between two known points, and came instead upon a miraculous new continent of matter, as rich and wonderful in its way as the Americas proved to be many years after their discovery. And, like Columbus, these modern discoverers of a new continent of vast resources did not themselves realize the nature and extent of their discovery. This was to be determined by later explorers, largely in America.

Meitner and Hahn had set out to repeat a famous experiment carried out by Prof. Enrico Fermi, Nobel Prize winning physicist, who left Fascist Italy to continue his work at Columbia University. Professor Fermi had discovered a strange game of "atomic golf," in which atomic balls, known as neutrons (fundamental, electrically neutral building blocks of the universe), could be made to score "holes in one" with much greater frequency if they were made to travel with slow speed, the "hole" in this case being the nucleus, or core, of the atom.

Through-the-Looking-Glass

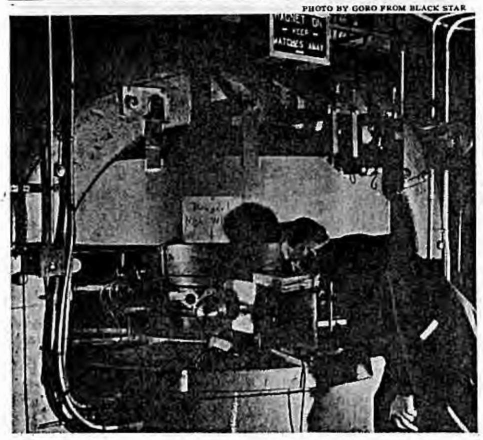
THE purpose of this game is to liberate part of the enormous energy locked up in the nucleus of the atom. In playing this game, using uranium as the "atomic golf course," Professor Fermi observed strange Alice-Through-the-Looking-Glass phenomena that did not seem possible. It appeared that in the course of this game new elements had been created heavier than the



A GLOBE PHOT

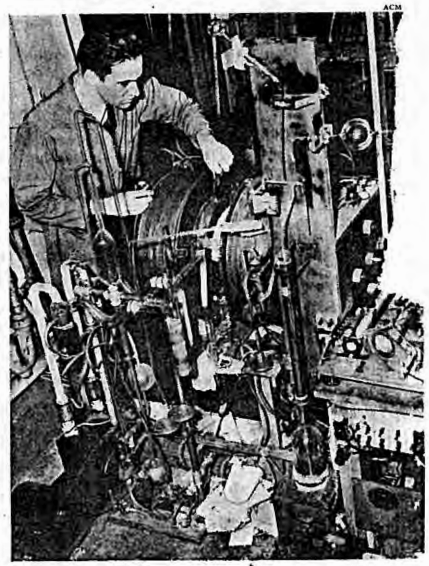
One of science's Big Berthas in the war on the atom, the 65-foot atom smasher of the Westinghouse Laboratories. Below, at work—Dr. Alfred O. Nier, 27-year-old Minnesota physicist, who was first to get a pure sample of U-235, a pound of which would have the explosive power of 15,000 tons of TNT.

PHOTO BY GORO FROM BLACK STAR



Columbia University's Dean Pegram, looking into an operation of his school's giant cyclotron (atom-smashing apparatus), with which it was confirmed that the uranium atom could be split in halves.

ACM



heaviest found in nature, elements beyond uranium, heavyweight of the natural components of the physical universe.

Meitner and Hahn devised a highly delicate "atomic microscope" that enabled them to "see" what was happening chemically on the "atomic golf course" more clearly than could be done before, then proceeded to fire slow-speed neutrons à la Fermi at the uranium nucleus. And the result surprised and startled them so much that they believed some serious error had been made. They repeated the experiment, only to observe once again what they had seen in the first place—an "atomic ghost" that had no business being there. Instead of an element resembling uranium they observed an element totally different, having an atomic weight only little more than half the weight of uranium. The "atomic ghost" was seen to materialize itself, and lo, here, out of nowhere, appeared the element used in the taking of X-ray pictures of internal organs—barium.

A Deep Mystery of the Laboratory

BARIUM! How the deuce did it get there? Where could it have come from? There definitely was not a trace of barium present when the experiment was started, and yet here it was. It was like placing a duck's egg in an incubator and suddenly seeing it hatch out into a chicken.

Before a solution could be found to this scientific mystery of the first magnitude, Hitler's racial decrees brought Doctor Meitner's career in Germany to an end. It had been discovered that Doctor Meitner, a scion of a family that had lived in Germany for many generations, was not "Aryan." She was forced to leave her native land to seek a haven where she could resume her life's work.

Lise Meitner was on the train bound for Stockholm, sadly looking out of the window at the Berlin where she had spent her life devotedly in the pursuit of knowledge. That was a closed chapter. She was sixty years old, unmarried, and a woman without a country. She was going to a strange land, where she would try to resume her work, her unfinished strange experiment, barium.

She could not get barium out of her mind. Could it have been an impurity? Doctor Hahn was the most careful of chemists. He had been meticulously careful to exclude any possibility of the uranium being contaminated with barium, and yet, in spite of the most careful precautions, the barium appeared, like Hamlet's ghost on the ramparts. Where could the barium have come from? Nothing ever comes from nothing, and there had been no barium there to start with.

Lise Meitner's thoughts wandered far afield and kept coming back to barium. Suddenly, what seemed at first an idle thought, to be dismissed as daydreaming, flashed into her mind. Barium has about half the atomic weight of uranium. Could it be possible that the bombardment of the uranium with the slow-speed neutron bullets split the uranium atoms in two nearly equal halves, one of which was the mysterious ghost of barium that appeared in the experiments?

She attributed the thought as most likely being due to the strain she had been under during the past few days. It was too fantastic to be true. For nothing like it had ever happened before in the hundreds of thousands, if not millions, of atom-smashing experiments in leading scientific institutions all over the world, during the past twenty years. Not even the most powerful atom-smashing machines in America, largest of their kind anywhere in the world, had ever succeeded in chipping off more than a small bit of an atom. Even an elementary student of physics knew that there was not enough power available anywhere on earth to split an atom in halves, particularly the heaviest of all the elements.

She began jotting down figures on paper. Every well-informed layman knows by this time that the material universe is made up of ninety-two fundamental elements, beginning with hydrogen, the lightest, at No. 1, and ending with uranium at ninety-two. What makes the elements differ from one another is the number of positively charged electrical particles, known as protons, in their nucleus, or core. Thus hydrogen has only one positive electrical particle in its nucleus. Helium has two. Carbon has six, nitrogen seven, oxygen eight, and so forth. If helium were to be split in halves, each half would be not helium but hydrogen. If oxygen were to lose one positive particle (proton) it would no longer be oxygen but nitrogen. Mercury contains eighty positive particles in its nucleus and gold has seventy-nine; hence if one of these could be knocked out of the mercury nucleus it would be transmuted into gold. Similarly, uranium contains ninety-two, barium fifty-six, and krypton thirty-six positive particles respectively, in their central core. Hence, if uranium could be split by some process into two uneven pieces, of fifty-six and thirty-six units each, the broken parts would be, respectively, barium and krypton.

56 and 36 and Energy Undreamed Of

HAVING scribbled the figures 56 and 36 on her notebook, Lise Meitner began doing a little more involved calculation. It takes tremendous energy to hold the unit particles in the central core of the atoms together. This is known as the "binding energy" of the atom. If an atom were to be broken in halves a certain portion of this binding energy would be released, and, in the case of a heavy atom, the amount of such binding energy that would be released should be of tremendous proportions. How much? she wondered. With expert mathematics she quickly arrived at the result and then went over her figures to make sure. . . . Yes, she was right. If a uranium atom of ninety-two positive particles were to be split into two parts, one of which consisted of 56 (barium) and the other of 36 (krypton) particles, the amount of atomic binding energy released would be the hitherto-undreamed-of figure of the order of 200,000,000 electron volts per atom, an energy 5,000,000 times greater than that released in the burning of coal.

The figures before her overwhelmed her. She was experiencing sensations that must have been akin to those of Columbus when he first sighted land, without knowing exactly what the land was. Was it the East Indies? A mirage? A new continent of untold wealth? If her figures were right, and they could well be checked, she and Doctor Hahn had accidentally stumbled upon (Continued on Page 60)

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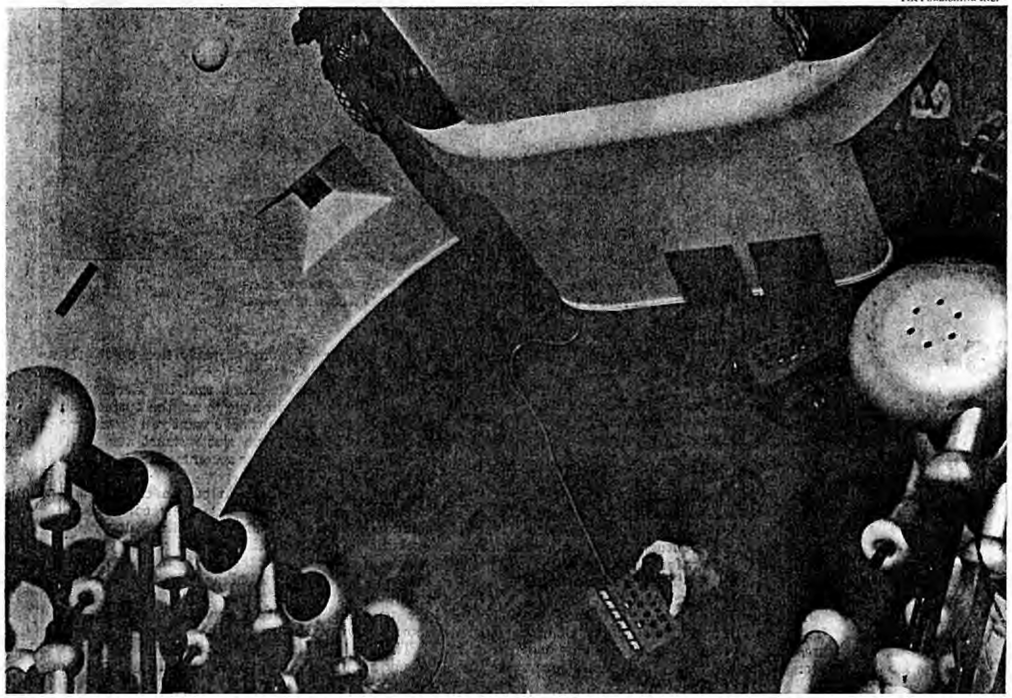


WIDE WORLD

Dr. Winfield W. Salisbury, busy on the ions of the University of California's 225-ton atom smasher, world's largest.

Today Germany is neck-and-neck with this country in the race to develop the full powers of U-235. At left, Berlin's atom-smashing plant, which German press agents claim is the largest in the world.

THE ATOM GIVES UP

(Continued from Page 13)

one of the greatest discoveries of the age. They had come upon the trail of what might lead to the shores of the Promised Land of Atomic Energy.

When Lise Meitner arrived in Stockholm she did two things that started off a set of events as dramatic as any in the history of man's endless quest for new means of mastery over his material environment. First, she prepared a report of the results of her strange experiment for a scientific journal, so that scientists in other parts of the world, both inside and outside Germany, might take up the quest for an answer to the puzzle. Second, she telegraphed the gist of her findings to a scientist friend in Copenhagen, Dr. R. Frisch.

It so happens that Doctor Frisch is the son-in-law of Prof. Niels Bohr, of Copenhagen, Denmark, one of the world's most famous pioneers in the investigation of the atom. Professor Bohr was at that time—it was January, 1939—in America, carrying on investigations with his colleague, Einstein, at the Institute for Advanced Study, Princeton, New Jersey, and also with his other Nobel Prize winning colleague, Fermi, at Columbia. Doctor Frisch did two things. He at once cabled the news from Doctor Meitner to Doctor Bohr in America, and he set to work repeating the Hahn-Meitner experiment in Doctor Bohr's physics laboratories at the University of Copenhagen.

The news reached Doctor Bohr on or about Tuesday, January 24, 1939. He lost no time in communicating the startling developments to Doctor Fermi. These two master minds in modern science began making some calculations of their own. Without knowing the full details of Doctor Meitner's figures, they soon arrived independently at the same conclusions. Sure enough, if the uranium atom could be split into two pieces, the parts would fly apart like gigantic atomic cannon balls, the greatest ever produced in any laboratory, each fragment traveling with an energy close to 100,000,000 electron volts, or a total of 200,000,000 electron volts of energy, by far the greatest ever liberated anywhere.

A Surprise for the Physicists

If their calculations were right then the "atomic thermometer" of Columbia's giant atom-smasher should register the fact. They called together a conference of the Columbia atom-smashers, headed by Prof. J. R. Dunning, under the general supervision of Dean George B. Pegram. For a day and a night they labored, preparing, testing, checking, observing. Then, on Wednesday, January twenty-fifth, their labors were finished—a tired group of scientists were anxiously standing around the "atomic thermometer." One of them pressed a button. Yes, the uranium atom was definitely being split. Little David was cracking nature's Goliath in two and forcing him to give up an enormous amount of his strength.

It so happened that on Friday following the experiments there was to be held at George Washington University, Washington, D. C., a conference on theoretical physics in which Doctor Bohr, Doctor Fermi, and a select group of leading American physicists were scheduled for informal discussions on the latest developments in their probings inside the atom.

There was nothing to indicate that anything out of the ordinary was about to take place when Doctor Bohr rose to speak that afternoon of January 27, 1939, in one of the lecture rooms at George Washington University. It took some minutes before the import of what he was saying, in low, even tones, had impressed itself on their critical minds. Had anyone other than the great Bohr, or another of his stature, uttered the words they were hearing it is doubtful if they would have taken them seriously.

The Atom-Smashers Get Busy

Suddenly there was a commotion and the room became nearly empty. Calm young scientists, leaders in their field, never observed to show undue excitement about anything, were seen rushing to the nearest telephones. One or two science reporters present sensed there was something momentous in the air, but the young physicists were too busy to talk to them. Excitedly they got their colleagues in their laboratories on the telephone. Bohr has just reported something tremendous. Sounds fantastic, unbelievable, but they must get hold at once of a sample of uranium and repeat the experiment Doctor Bohr had just told them about. Columbia had already done it, but they must not lose time to do it on their own.

In almost no time the giant atom-smashers at the Carnegie Institution of Washington, Johns Hopkins University, and a number of other leading scientific institutions, were engaged in a blitzkrieg against the uranium atom, hurling against it billions upon billions of atomic projectiles in the form of slowed-up neutrons. There was no sleep that night in January for any of these scientists in the laboratories of various parts of America, and they kept working on through the morning and into the afternoon.

Finally, late Saturday afternoon, the news came through to the group of physicists at the Washington conference. It was true. The barium came as a result of the uranium atom having been split in two unequal pieces, releasing in the process a quantity of atomic binding energy 5,000,000 times the energy of burning coal.

Then came word from Doctor Frisch by cable to Doctor Bohr that he had achieved the same results a few days ahead of the Americans.

No sooner was the great barium mystery solved than another, equally baffling, presented itself. When the uranium is split in two parts a number of high-speed atomic bullets, in the form of neutrons, should be released in the process from the atom's core. If these neutrons were to be slowed down (slow neutrons are the most accurate) they should start a cyclic action in the manner of a string of firecrackers, one split atom automatically setting off another, which, in turn, would set off a third, and so on, in rapid succession, resulting in a terrific explosion.

When no such explosion was observed, and no chain reaction in the manner of "cosmic firecrackers," the scientists set to wondering. There must be something that extinguishes the cosmic fire. What could that something be?

Doctor Bohr, in collaboration with Dr. J. A. Wheeler, of Princeton, was the first with a theoretical explanation for the problem. Ordinary uranium, it had been found by Doctor Dempster in 1935, consisted of a mixture of three types of the substance differing in their atomic weight, the largest part consisting of atomic weight 238, while the two other types had atomic weights of 235 and 234, respectively. It had also been determined that the ratio of the uranium 238 to uranium 235 was 1 to 139—that is, in every 140 pounds of ordinary uranium there is one pound of pure uranium 235 (U-235), scattered so finely that the job of separation had up till then been regarded as impossible. Uranium 234 is much the rarest of the three, existing in a ratio of 1 to 17,000 of ordinary uranium.

It was the U-235, Doctor Bohr and Doctor Wheeler concluded on the basis of theoretical reasoning, that was starting the atomic fires going. The U-238 was the element that was quenching the fires. If only a sample of the U-235 could be obtained in pure form! But no such sample was available, and until that could be done the world could not know for certain.

Quietly, and it may be imagined feverishly, another scientific race was set going in our leading scientific laboratories. The industrial research laboratories of the General Electric Company, fully realizing what was at stake, joined in the race with improved apparatus. And the race gained impetus by reports that kept trickling out of Germany, through a grapevine in which exiles from German laboratories played a significant part.

Shortly after Lise Meitner was exiled from Germany, Doctor Hahn published a preliminary report on the experiment in a German scientific journal in which he confined himself to the facts, without interpreting them. Since the spectacular corroboration of the experiment, and its full significance, has been published in America not a word has come out officially from German laboratories. But in spite of the strict censorship, and the thick veil of secrecy, reports began trickling through, all fitting together the scattered parts of a jigsaw puzzle. By direct order of Hitler, according to the reports, some 200 of Germany's greatest scientists were concentrating all their joint energies on the solution of the one problem—U-235.

The problem of separating twins of the same element so close to each other in weight was a formidable one and required a considerable amount of experimental ingenuity for its solution. Credit for being the first in the field with a tiny sample of the precious substance goes to Dr. Alfred O. Nier, twenty-seven-year-old physicist of the University of Minnesota. Shortly thereafter another, slightly larger, sample was isolated at the General Electric research laboratories at Schenectady, New York, by Dr. K. H. Kingdon and Dr. H. C. Pollock. Both samples were rushed to Columbia University and submitted to tests, and both provided experimental proof that Doctor Bohr and Doctor Wheeler were right in their theoretical predictions that it was the U-235 that had been split in two and released the greatest amounts of atomic energy ever to be observed.

These first microscopic bits of U-235 may, therefore, well be regarded in the not-too-distant future as the very cornerstone of a new civilization. Fifty years from now, when the present war may be but a memory, the generation then living may look upon this discovery as one of the turning points in human history. Certain it is that it will be regarded as one of the great discoveries in modern science.

But nature has a way of tantalizing man by placing before him a luscious morsel and then interposing seemingly insuperable obstacles between him and the desired object. No sooner was the discovery made of the tremendous power-potentialities of U-235 than it was realized that nature had locked it up so tightly with ordinary uranium that it was, to all intents and purposes, impossible to separate it in pure form in large quantities. The methods used for separating the first tiny samples at the University of Minnesota and the General Electric Company yielded the substance at the rate of 1036 millionths of a gram every ten days, working

"You mustn't pay any attention to him if he asks you for some doughnuts, Mrs. Wilson. . . . We're supposed to wait until you offer them."

twenty-four hours a day. At this rate it would take 26,445 years to produce one gram, and 11,995,074 years to extract one pound. It was, therefore, at once realized that the principal problem to be solved before atomic power could become a reality was to devise a method, or methods, that would make possible the extraction of U-235 in practical quantities.

The prize at the end of the rainbow was in itself great enough to start a friendly scientific race among America's leading university and industrial laboratories. But this friendly race, usual among scientists as among the rest of mankind, assumed an ominous aspect as the tentacles of the swastika cast a shadow on the tranquil walls of our laboratories. For here again it was realized that, with all their superior equipment and ingenuity, the American scientists, because of the very limited funds available for research, were at a considerable disadvantage in working against scientists of totalitarian Germany, who had practically unlimited resources at their disposal. What if the Germans succeeded in attaining their goal? A few hundred pounds of U-235, even in a concentration of only 10 to 50 per cent purity, according to calculations, would place in German hands potentially the most powerful fuel ever dreamed of.

It is the prevailing opinion among American scientists that, in spite of the enormously greater resources at the disposal of the German laboratories, they could not possibly solve the problem in less than ten years, and probably much longer. Yet developments in science move so fast these days that no one is willing to make definite predictions as to what might, or might not, be done in the near future.

The Problem of Isolating U-235

Even now there are signs on the horizon promising considerably improved methods for the separation of U-235 in larger quantities. A number of new methods are being quietly developed in American laboratories, and one of them in particular, known as the "thermal-diffusion method," taking advantage of differences in temperature to separate lighter particles from their heavier components, is being thoroughly investigated as the most promising for the present.

The development of this method furnishes another fine example of the fact that progress in modern science is the result of contributions by many scientists in many lands. The method was originally developed in Germany for other purposes a few years ago. Later it was improved upon in America. More recently, Prof. W. H. Furry, of Harvard, Prof. Lars Onsager, of Yale, and others, worked out by mathematics a theory for employing the method with greater efficiency. Taking advantage of all these contributions, Prof. Wilhelm Krasny-Ergen, of the University of Stockholm, Sweden, designed an apparatus last summer which, he believed, would increase the yield of U-235 more than 12,500 times over present methods, provided certain chemical compounds of uranium could be produced.

Unfortunately, the invasion of Norway brought Doctor Krasny-Ergen's work to a stop before he had even completed his apparatus, so that for the present it still remains a purely theoretical calculation, and with no one willing to swear that the theory behind the calculations is watertight. All that scientists are willing to say now is that "it appears probable that it will work," but that "there may be several years of concentrated work needed before success is reached." Even then, when U-235 is obtained, they add, "there is the very serious problem of shielding the operators from the U-235's radiation." The screens may have to be so bulky as to prohibit the use of the material as a lightweight power source.

Moreover, practical scientists point out, even if the Krasny-Ergen method did work, a method that increases the rate of yield by 12,500 times would still be very slow, requiring some 350,000 days (960 years) for the isolation of one pound.

Future Power Possibilities

However, still speaking theoretically, this would be true only for one unit of the apparatus. If the apparatus should be found to work, and scientists believe that it probably would, the problem would become largely an economic one. If it would take 350,000 days for one unit to produce one pound, then 1000 units would produce a pound in 350 days, and 100,000 such units, easy and cheap to make, would yield one pound of U-235 every three and a half days.

In a country like Germany, with its totalitarian economy, the cost of any undertaking is a very minor consideration when the government decrees that it is vital for the national economy, and, if the reports are correct, the Nazi government has so decreed.

One pound of pure U-235 would have the explosive power of 15,000 tons of TNT, or 300 carloads of fifty tons each. But such a substance would not likely be wasted on explosives. A five-pound lump of only 10 to 50 per cent purity would be sufficient to drive ocean liners and submarines back and forth across the seven seas without refueling for months. And the technique that would be required for its utilization would be even more simple than the burning of coal or oil, according to present theories based on small-scale experiments.

Just as coal needs a fire to release its energy, the U-235 would need only water. All that would be needed to start it would be to place it in water. The water would first be turned into steam and the steam would run powerful turbines.

When all the water had been used up the process would automatically stop, until more water was supplied to start it again. A constant supply of cold water, well regulated, would keep the process going on for months, or even years, depending on the quantity of the U-235 present.

The basis for these theoretical considerations rests on the discovery by Professor Fermi that neutrons when slowed down, by being made to go through water, become thousands of times more accurate in hitting bull's-eyes square into the hearts of atoms. Fast neutrons have tremendous speed, but no control. They pass right through, or by, atoms without hurting them. Neutrons slowed down to low speeds, the lower the better, gain in control what they lose in speed. They go straight for the heart of the atom, and once they enter it they have not enough energy to get out. In the case of the U-235 atom, because of its bulk and inherent instability, the slow neutron, on entering, splits it in half. The splitting, it is believed, automatically releases other neutrons, which, slowed

down in turn, will split more U-235 atoms, starting a firecracker action in a process that would be both automatic and self-regulating.

The neutrons have a weight very close to that of hydrogen. Since two thirds of the atoms of water consist of hydrogen, the neutrons, on being made to pass through water, strike the equal weights of the hydrogen atoms, and in doing so yield up most of their energy, so that they are slowed down to speeds corresponding to energies of one fortieth of an electron volt (an electron volt is a very small fraction of an erg, or unit of work).

On being slowed down the neutron is said to become "tuned" to the central core of the atom, so that it heads straight for it. To use a golf analogy, the slow neutron behaves as though a golf ball were magnetized and aimed at a hole containing a powerful magnet. Even the poorest of golfers could, under such circumstances, make holes in one.

To start the fires of atomic energy burning in U-235 it would not be necessary, according to theory, to provide neutrons from an outside source. What are known as "free" neutrons are present everywhere in the universe. Cosmic rays that keep entering the atmosphere from the outside at all times during day and night, and minute amounts of radium present in the air, continually collide with the oxygen and nitrogen atoms in the atmosphere with such force that fast neutrons are liberated. When a piece of U-235 will be placed in water, these fast neutrons would therefore be slowed down and start the automatic release of atomic energy, as long as there was water at the proper cool room temperature. Hot water, or steam, would not slow the neutrons down sufficiently to be effective.

Energy Still Untamed

Tremendous as the release of atomic energy from U-235 is, it must be realized that it constitutes only a very small fraction, less than one tenth of 1 per cent, of the total power contained in the U-235 atom if its mass could be completely utilized as energy. Each unit of atomic weight has an equivalent in energy of a billion electron volts, so that U-235, having 235 such units, contains the enormous energy of 235,000,000,000 electron volts, or 1175 times greater than the 200,000,000 electron-volt energy yielded by the splitting of the U-235 atom. In other words, if all the mass of one pound of U-235 could be converted into energy it would yield the equivalent in power of 5,875,000,000 pounds of coal. Stated in other terms, one pound of U-235 contains a total energy of 10,000,000,000 kilowatt hours of electricity, of which only less than one tenth of 1 per cent, or 10,000,000 kilowatt hours, could be utilized by the splitting of the U-235 atoms with slow neutrons.

Not even in the stars and sun is the entire mass of atoms converted into energy. It has been calculated that one thirtieth of a gram of water (there are 453.59 grams per pound), converted into pure energy, would yield enough heat to turn 1000 tons of water into steam. In one whole gram of water there is a sufficient store of energy to raise a load of 1,000,000 tons to the top of a mountain six miles high. A breath of air would operate a powerful airplane continuously for a year; a handful of snow would heat a large apartment house for a year; the pasteboard in a small railroad ticket would run a heavy passenger train several times around the globe; a cup of water would supply the power of a great generating station of 100,000-kilowatt capacity for a year.

For the Research Laboratories

Writing in the General Electric Review for June, 1940, Doctor Kingdon sums up the general attitude of the research worker in the field as follows:

> While it seems unlikely that this energy source will displace our present means of getting power, it cannot be denied that such a source should have important applications, as it is estimated that several million times as much power could be obtained from U-235 as from an equal weight of coal. These applications will involve problems of proper control of the power, and protection against the tremendous neutron and X-ray radiations which will accompany it. It may be that the use of these radiations in therapy will be one of the most important applications. But detailed discussion of these questions is premature until further progress has been made in the separation of large quantities of U-235.

Indeed, it would be just as premature to discuss in detail the possible applications and potentialities for the future of U-235 as a new source of power as it would have been to discuss the potentialities of the electromagnetic (radio) wave when it was first produced by Hertz, or of the steam engine, dynamo, internal-combustion engine or airplane, when they were first invented. For the next few years, at least, operators of coal mines and oil wells, and distributors of power need not lose sleep over U-235.

Nevertheless, it would be lacking in farsightedness for our industrialists not to watch with keen interest the developments in this field, and it would be downright shortsighted not to aid the pioneer scientists in this highly important research so that America may be in the lead when the time comes for the practical application of this tremendous new potential source of power. It would be tragic indeed, if America were to lose the lead it is now believed to have in this field because its scientists, as the result of lack of funds, could not keep up in the race with their totalitarian rivals. A few thousands of dollars invested for research now may be worth hundreds of millions in the future.

Fortunately, the indications are that some of our leading industrialists and public-utility leaders are already taking a keen interest in the matter. This is shown by the fact that at a round-table discussion in April to "explore the public utilities outlook" for the immediate future, under the auspices of the Savings Bank Journal, attended by more than thirty industrial and political authorities in the field, U-235 was one of the topics discussed, and, according to an editorial comment in the Savings Bank Journal for May, 1940, "aroused great interest and speculation."

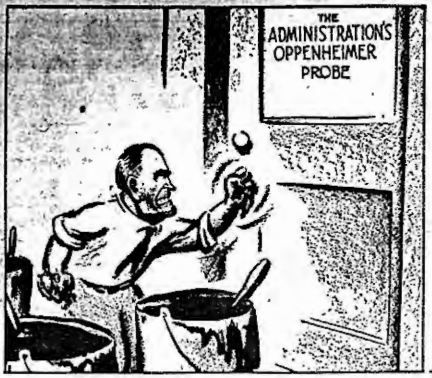
Correction

AN ARTICLE, Good-by, Boys, I'm Through, by Joseph F. Dinneen, in the issue of August third, stated: "For months the Guild had supported a strike against the Newark News." This was incorrect. The American Newspaper Guild strike to which the article referred was against the Newark Ledger. The Post regrets the error and is glad to correct it.

[Econ. Ext. - Times

File Atomic File

HOW EIGHT CARTOONISTS REACTED TO THE DEVELOPMENTS IN THE OPPENHEIMER CASE



Little in The Nashville Tennessean

"Who slammed that door in my face?"

Herblock in The Washington Post and Times-Herald

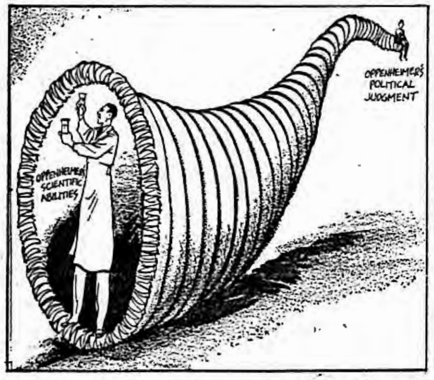
"Who's being walled off from what?"

Kuekes in The Cleveland Plain Dealer

"The shadow."

Rosen in The Albany Times-Union

"Now this!"

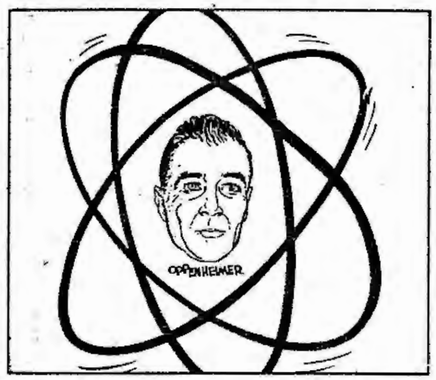


Morris, A. P. Newsfeatures

"The other end of the horn."

Hutton in The Philadelphia Inquirer

"Time out for thinking."



Dobbins in The Boston Post

"'O' Bomb?"

Burck in The Chicago Sun-Times

"Don't tell anyone—all you do is split a scientist."

THE DRAMA OF THE HYDROGEN BOMB—AND DR. OPPENHEIMER'S KEY ROLE

Security Case Focuses Attention on Disputes That Preceded First Successful Test of H-Bomb at Pacific Proving Ground

By E. W. KENWORTHY

Fifteen years ago this month a paper in the Physical Review set the United States on the course that led to Eniwetok. Those years wrought greater changes than any comparable period in the whole sweep of history. What follows is a brief account of the H-bomb, the men who made it, the problems it poses.

1. THE BEGINNINGS

The atomic age began theoretically in 1905 when Albert Einstein advanced the proposition that matter could be converted into energy.

It began actually thirty-three years later in the Kaiser Wilhelm Institute not many miles from Hitler's Chancellery. On a day late in 1938, physicists Otto Hahn and Fritz Strassman proved the Einstein theory by bombarding uranium with neutrons. The uranium went forward, the Government began planning production. In the fall of 1942, Maj. Gen. Leslie R. Groves was made head of the over-all Manhattan Engineer District. Before the year was out, the M. E. D. had begun the construction of the vast U-235 complex at Oak Ridge, Tenn., and the plutonium plant at Hanford, Wash.

At the same time, General Groves acquired a site in the New Mexico desert—the Los Alamos Ranch—about thirty-five miles from Sante Fe. Here in April, 1943, the Los Alamos Scientific Laboratory was set up to work on the actual bomb. The man put in charge of Los Alamos was J. Robert Oppenheimer, a theoretical physicist from Berkeley.

2. THE TRIGGER

Dr. Oppenheimer's plans called for an initial staff of 100 highly

was the draftsman, David Greenglass, who worked on a lens mold. On a Sunday morning in June, 1945, he met Soviet agent Harry Gold in Albuquerque, and gave him drawings of the bomb.

For the scientists at Los Alamos, life was made up of problems, heartbreaks and triumphs. It was an austere, dedicated life. The problems were of a kind that required unhurried concentration. But the scientists worked under the awful urgency of knowing that the bomb could turn the tide of war and of not knowing how far along the Germans were.

Dr. Oppenheimer has telescoped

evidence of Soviet hostility and the growing evidences of Soviet power. * * *"

This massive evidence did not bring a reversal of the post-war cutbacks in American armed strength. Instead the nation placed its reliance on its A-bomb monopoly, confident that Russia would require at least five years and possibly ten to solve the riddle, by which time the United States would have a formidable stockpile. This confidence was vaporized on Sept. 23, 1949.

The Soviet explosion jolted the Government. Some officials urged on the President an all-out "crash" program to build "the Super"—the

war against cities—might encourage local aggression, it was argued.

Therefore, the scientists recommended concentration on large A-bombs; a family of atom weapons (already under way at Los Alamos) that could be used in tactical support of ground troops, and an enlarged air defense network.

Within the A. E. C., Chairman David E. Lilienthal (below, talking with Senator Brien McMahon), Sum-

than in warning all mankind to avert it."

Again dealing with the dangers of using the Super as a deterrent, he said that this may be "a fine thing," but he asked, "What happens if the fighting starts?" He quoted Admiral Ralph A. Oftsie: "[When we talk of strategic bombing] we are talking of attacks on cities. * * * The idea that it is within our power to inflict maximum damage upon the enemy in a short time without serious risk to ourselves creates the delusion that we are stronger than we actually are."

The whole question of national policy had obviously become vastly complex. The scientist was no longer merely the hand-maiden to the military, nor the consultant to the civilian policy-makers. Inevitably he found himself thrust—or because of deep concern, thrust himself—into questions of military strategy and

article appeared, Admiral Strauss became the new chairman of the A. E. C. Four days after he took over, he ordered the removal of classified documents from Dr. Oppenheimer's custody, pending a review of his security file.

On Aug. 8, Malenkov announced that the American monopoly on the H-bomb had been ended.

Detection instruments not only confirmed this statement, but indicated—from the force of the explosion—that the Russians had repeated Dr. Teller's invention. A tritium explosion of that force—the scientists believed—would have required an expenditure of atomic fuel which the Russians would probably not have invested on a test.

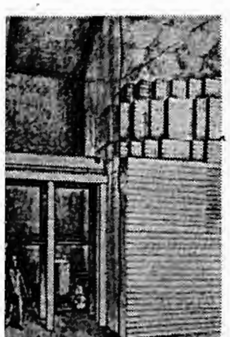
A mood something like frenzy took hold of Washington, and it did not soon subside. The peak was reached in the first week in October

om was split into lighter ele- ents; in the fission, some matter ıs converted into energy with ex- osive force. That small flash was e precursor of the A-bomb and e H-bomb.

Soon after, Lise Meitner, who orked with Hahn, fled Germany. e passed the news on to Niels ohr in Copenhagen. At a confer- ce later in Washington, Bohr and rico Fermi, a refugee Italian ysicist working at Columbia, put eir heads together. In April, 1939, rmi and Leo Szilard published paper on their own researches on e bombardment of uranium. Ein- ein read it. He, Szilard and Eu- ne O. Wigner of Princeton met th Alexander Sachs of the Leh- an Corporation to discuss the pos- ility of an atomic bomb.

On Oct. 11, 1939, Sachs read to esident Roosevelt a letter from nstein and a memo from Szilard. e President ordered an Advisory mmittee on Uranium to be set . In February, 1940, $6,000 was otted for the work at Columbia. June the Uranium Committee was ced under the newly created Na- nal Defense Research Committee ter the Office of Scientific Re- arch and Development) headed by . Vannevar Bush. After Pearl rbor, the decision was made to all-out.

Through 1942, the laboratory rk went forward at tremendous ed. At Columbia, the Substitute loy Material (SAM) Laboratory der Harold Urey was developing d testing the gaseous diffusion ocess of separating out the ura- um isotope U-235. At the Univer- y of California in Berkeley, entists in the Radiation Labora- y under the direction of Ernest Lawrence worked on the electro- gnetic process of separating 235. At the Argonne Laboratory the University of Chicago, physi- ts under Fermi were constructing pilot atomic pile (sketch below).



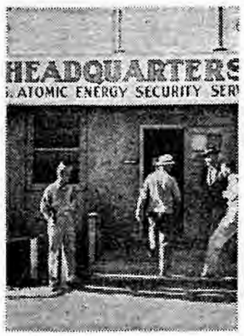
d at the end of the year the Metal- gical Laboratory under Arthur mpton began working on the pro- ction of plutonium. While the laboratory experiments

... trained scientists and technicians. By the spring of 1945, Los Alamos had a staff of nearly 4,000.

Recruitment was a terrific problem. The nation was at war. Most scientists were already engaged on other essential defense work. Life at Los Alamos was not an inviting prospect. It was a military post. The scientists were asked to sign up for the duration.

The burden of recruitment fell largely on Dr. Oppenheimer. For months he traveled about the country, persuading scientists of the urgency of the work they would be doing. His fervor was infectious. Few scientists refused him.

Security considerations had been uppermost in the selection of Los Alamos. But the Army did not rely on remoteness. The whole area was fenced and constantly patroled by armed guards like the one shown below. Mail was censored, all telephone



calls monitored. The scientists were permitted to leave the post only on business, or for the most urgent personal reasons. When they left, they were kept under surveillance.

There was good reason for the precautions. The Army Counter Intelligence Corps and the F. B. I. had ample evidence that the Communists knew much and were after more. Under the direction of Steve Nelson, openly the party organizer of the San Francisco Bay Area and covertly an NKVD agent in charge of atomic espionage, the Communists had managed to plant a small cell in the Radiation Laboratory at Berkley.

A few months before Dr. Oppenheimer had left for Los Alamos, the Communists had made approaches to him through an old friend. According to testimony in postwar Congressional hearings, Dr. Oppenheimer had replied that the giving of information would be "treasonable." But he failed to report the incident until several months after it occurred.

Despite all the precautions, Los Alamos was not spy-proof. For almost two years—from August, 1944 to June, 1946—Klaus Fuchs worked at Los Alamos, sitting in on the most secret sessions. At Los Alamos, also,

... words:

"Time and again we had in the technical work almost paralyzing crises. Time and again the laboratory drew itself together and faced the new problems and got on with the work. We worked by night and by day; and in the end the many jobs were done."

On July 16, 1945, this mushroom cloud rose out of the desert at Alamogordo.

On the day of Hiroshima, Secretary Stimson said:

"The development of the bomb itself has been largely due to his [Dr. Oppenheimer's] genius and the inspiration and leadership he has given to his associates."

Even as the bombs dropped on Japan, the scientists at Los Alamos were discussing the future of atomic energy. The fissionable atom, in a world at peace, could multiply the wealth of mankind. It could also, in a world not at peace, become the trigger for a vastly more powerful thermonuclear bomb.

3. THE HIATUS

In the fall of 1945, the nation knew little and cared less about H-bombs. The A-bomb was felt to be plenty big enough. It had stunned the world with its power. The problem was how to control it.

This was the Indian summer of large hopes—in the unity of the victors, in the United Nations, in permanent peace. United States forces were quickly brought home and demobilized. The Congress set to work on plans for civilian control of atomic energy. The Government set to work on plans for international control of atomic armaments.

The Indian summer became a cold winter and a false spring. In June, 1946, Russia flatly turned down the Baruch plan for international control of atomic energy. As Dr. Oppenheimer, who had been a consultant to Mr. Baruch, wrote later: "Openness, friendliness and cooperation did not seem to be what the Soviet Government most prized on this earth. * * * Instead we came to grips * * * with the massive

H-bomb. Among them was Admiral Lewis L. Strauss, a member of the Atomic Energy Commission. A tremendous controversy began in the most secret councils of the nation.

The Atomic Energy Commission in October called for a special meeting of the General Advisory Committee of scientists, of which Dr. Oppenheimer was chairman. The A. E. C. asked for an opinion on the "crash" program. The G. A. C. reported back before the month was out. Unanimously it opposed the crash program. Behind the committee's opposition were these considerations:

There was the question of feasibility. The committee estimated that with "an imaginative and concerted attack," there was a "better than even chance" of producing the H-bomb within five years. But there were tremendous technical difficulties to solve. Some scientists doubted whether the intense heat of the A-bomb could be concentrated long enough to set off the H-bomb.

There was the question of atomic "drain." At that time, plans called for using tritium as the key component in the H-bomb charge. The production of tritium would utilize facilities otherwise capable of producing plutonium for A-bombs. The scientists doubted whether this drain was justified when the nation already had A-bombs more powerful than those that had knocked out Hiroshima and Nagasaki.

There was also the question of defense. Dr. Oppenheimer (shown with Dr. Einstein below) felt strongly

that continental defenses could be strengthened.

Finally there was the big question of basing the nation's security chiefly on strategic atom-bombing. Many scientists agreed with top Army and Navy officials that the atomic bomb was not an "ultimate" weapon, and that there were many local situations in which it could not be used. The enemy's knowledge of the bomb's limitations — together with his confidence that the U. S. would not initiate a massive atom-

ner T. Pike, Dr. Henry D. Smyth aligned themselves with the Advisory Committee. Admiral Strauss and Gordon Dean dissented. The President turned the controversy over to Secretary of State Dean Acheson, Secretary of Defense Louis Johnson and Mr. Lilienthal. The three men met on Jan. 31, 1950. Mr. Acheson and Mr. Johnson favored the crash program. The committee walked across the street to the White House. The President listened to the arguments. That afternoon he gave the go-ahead on the H-bomb.

4. BUILDING THE BOMB

Work on the H-bomb got under way immediately at Los Alamos. In charge of the program was Dr. Edward Teller, the Hungarian-born physicist who had long been at work on the theoretical problems.

At the outset, planning was based on the assumption that the H-bomb would use tritium, and in January, 1951, ground was broken on a billion-dollar plant at Savannah River, South Carolina, to produce the tritium.

Meanwhile, however, Teller was working on a revolutionary scheme that might obviate the need of tritium. At Eniwetok in the spring of 1951, it was reported that a device was tested which established the soundness of his theory. From then on things moved with tremendous speed. Teller was installed at the A. E. C. laboratory at Livermore, Calif., which became the Los Alamos of the H-bomb.

As the work on the H-bomb continued, so did the controversy. The scientists who had warned against excessive reliance on strategic atomic bombs found point for their warnings in the Korean war.

In a speech to the New York Bar Association in January, 1951, Dr. Oppenheimer raised again the question of the military uses of the atom as against the political uses as a deterrent:

"They [atomic bombs] are not primarily weapons of totality or terror, but weapons used to give combat forces help that they would otherwise lack. Only when the atomic bomb is recognized * * * as an integral part of military operations will it really be of much help in the fighting of a war, rather

... diplomacy.

The excursions of the scientists into the realm of policy, and especially after decisions had been made, aroused some resentment in high quarters. It is not known whether this resentment was one of the reasons that Dr. Oppenheimer was not reappointed to the General Advisory Committee when his term expired in June, 1952, but was only made a consultant for one year.

On Nov. 2, 1952, the first H-bomb (below) exploded at Eniwetok.

5. THE HYDROGEN AGE

The United States now had a Super-monopoly. The nation found some comfort in it, but not nearly so much as it had found in the A-bomb monopoly. The man in the street knew instinctively what the atomic physicist knew positively—that if the Russians could master the A-bomb, they could master the H-bomb, and that it would be only a matter of time before instruments in the free world would pick up radiation waves let loose in the fastnesses of Siberia.

The knowledge intensified the old controversy. But now there was intense public interest in the debate.

In public speeches the debate was earnest and temperate. But behind the scenes there were rumors, allegations, suspicions and charges, and some of these found their way into print. In May, 1953, Fortune Magazine ran a piece on "The Hidden Struggle for the H-bomb," which said that Dr. Teller "had reason to believe" that the Atomic Energy Commission "under Oppenheimer's influence" had tried "to postpone, if not stifle," the building of the H-bomb, and that Dr. Oppenheimer had "tried to stop the test" at Eniwetok.

Two months later an article by Dr. Oppenheimer on "Atomic Weapons and American Policy" got wide attention. He laid great stress on the need for defensive measures, and the need for "candor" with the American people and our Allies. He criticized "the great rigidity of policy."

In the week the Oppenheimer

when Defense Mobilizer Arthur S. Flemming said that Soviet Russia had the capacity to deliver "the most destructive weapon ever devised * * * on chosen targets in the United States"; Secretary of Defense Wilson said Russia was "three or four years back of where we are"; and W. Sterling Cole, chairman of the Joint Congressional Committee on Atomic Energy, asked for expenditure of "10 billion a year on continental defense.

The President stepped in, saying that the Russians had the capacity to make "an atomic attack on us." He put an end to widespread reports that the Administration would launch "Operation Candor," a series of speeches on the whole atomic situation. He said, "We do not intend to disclose the details of our strength * * *." In mid-December he made his proposal for an atomic pool for peaceful purposes. Two weeks later, Dr. Oppenheimer (shown with physicist Hans Bethe)

was called in by Admiral Strauss and given the alternative of resigning as consultant to the A. E. C. or facing a security hearing.

The March tests at Bikini raised a new storm, as the nation and world were shown pictures of the 1952 explosion that obliterated a small island and were informed by Admiral Strauss that the March 1 blast would have destroyed Manhattan.

The President said the U. S. saw no need for building a bigger bomb. This did not dispel the fears, for the nation was also told that if the Bikini bomb were encased in a cobalt sheath, the explosion would send a deadly radioactive cobalt dust cloud over thousands of square miles.

"Knowledge comes," said Tennyson, "but wisdom lingers." The world now had the knowledge to destroy itself. The question was whether it could command the wisdom to save itself.

PICTURE CREDITS

Photos in the above article were taken by U. S. Army, U. S. Air Force, Associated Press, The New York Times (Gertrude Samuels).